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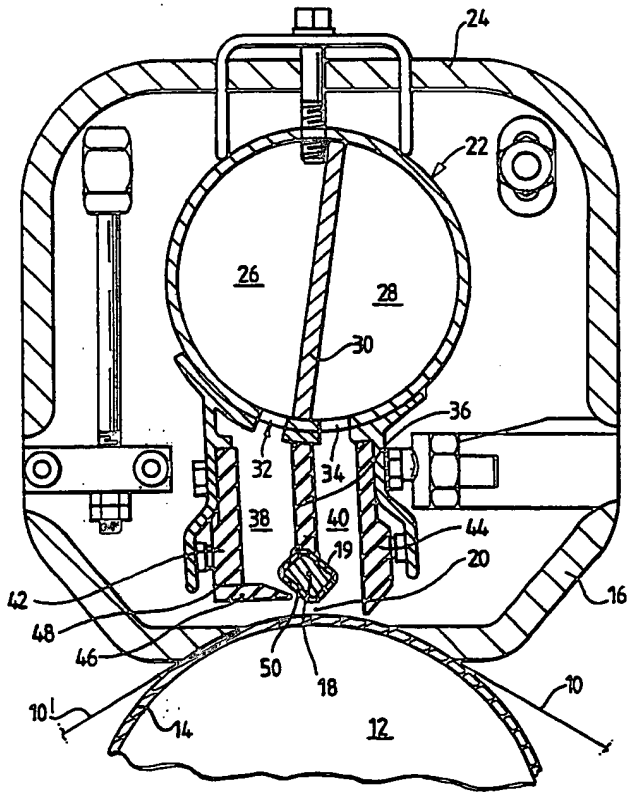
(54) Title: WEB CLEANING APPARATUS

(57) Abstract

In known non-contact web cleaners, clean air at high velocity is passed over the surface of the web to remove debris. However, these web cleaners can only remove particles down to a certain size due to the boundary layer produced over the surface of the web by the high velocity air stream. Electrostatic charges are also used to neutralise the charge which may be attracting the debris or dirt to the surface of the web. Electrostatic cleaning is only effective at low web speeds. Described herein is a method and apparatus which produces alternating electrostatic forces to separate particles from the surface of the web in the region of the boundary layer. The apparatus utilises an electrode (18) to produce a corona discharge in a gap (20) formed between the electrode (18) itself and the surface of the web (10) being treated. An air supply arrangement (22) is provided to supply air to and remove air from the gap (20) to remove the particles which have been lifted from the surface of the web (10) due to the corona discharge.



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WEB CLEANING APPARATUS

This invention relates to web cleaning apparatus, and is more particularly concerned with non-contact web cleaning apparatus.

In known non-contact web cleaners, clean air at high velocity is passed over the surface of the web to remove debris. It is also known to utilise electrostatic charges to neutralise the charge which may be attracting the debris or dirt to the surface of the web.

US Patent Specification US-A-2920987 describes an arrangement which can be used to clean the surface of a non-conducting material. A high alternating voltage supply is applied to the material by means of an electrode positioned adjacent one surface of the web. This alternating voltage damps out the static charge present on the surface of the material due to a previous operation, for example, a grinding operation. Arranged on the opposite side of the material to the electrode is a series of projections which contact the material. Particles on the material after the grinding operation, say, are removed due to the electrostatic effect produced by the electrode and the physical contact of the projections with the material itself. Loosened particles are removed from the surface of the material by suction.

Another arrangement in which alternating voltages are used to assist in the removal of particles from the surface of a web is described in US Patent Specification US-A-2980933. In this arrangement, the web is passed through two static electrostatic fields of opposite charge, an air stream being used to remove the particles loosened by the oppositely charged electrostatic fi lds.

US Patent Specification US-A-4213167 discloses an arrangement in which both surfaces of a

web are cleaned by causing air to flow over both surfaces, and introducing ions into the air flow to neutralise static charge on the web. Other examples of the use of ionised air streams to remove dust are disclosed in US Patent Specifications US-A-4454621 and US-A-4241377.

US Patent Specification US-A-4835808 discloses an arrangement which utilises both suction and blowing to remove particles from the surface of a web. A field plate is also used to charge the web and an electrode is used to discharge the web thereby removing the particles. US Patent Specification US-A-3536528 also discloses the use of suction and blowing to remove particles from the surface of a web, but in this case, the charge on the web is neutralised after cleaning.

In arrangements which utilise air at high velocity to remove loosened particles from the surface of a web, there is a lower limit to the size of particle which can be removed. This limit is due to the thickness of the boundary layer produced over the surface of the web by the high velocity air stream. The thickness of the boundary layer can be reduced by increasing the air velocity, but a practical limit is approximately 30µm on a smooth surface and more than this on a rough one.

Web cleaners which use ions to discharge the electrostatic charges holding particles against the surface of the web are only effective at low web speeds. However, this may prevent particles being re-attracted to the web after they have been loosened.

It is therefore an object of the present invention to provide improved web cleaning apparatus which produces sufficient force using alternating electrostatic fields to separate particles from the surface of the web, in the boundary layer region, so that they can be removed from the surface of the web.

According to one aspect of the present invention, there is provid d a meth d of cleaning web material comprising passing the web through an air gap, and removing particles from the web, characterized in that a corona discharge is produced across the air gap thereby generating electrostatic forces on the web and on the particles which cause at least some of the particles to lift off the surface of the web.

Preferably, the corona discharge is produced by an alternating voltage supply.

According to a second aspect of the present invention, there is provided web cleaning apparatus for use in a method as described above which comprises a first surface, a second surface spaced from the first surface and defining an air gap therebetween, generator means for producing a corona discharge in the air gap, and means for removing particles loosened by the corona discharge.

At least one of the first and second surfaces is an insulating surface so that the corona discharge does not only occur at a single point.

The generator means may be a high voltage alternating supply.

Once the particles have been loosened, they can be removed using a high velocity air stream. Additionally, or alternatively, suction means can be used to remove the loosened particles.

In a preferred arrangement, the generator means operates at a frequency between 1 to 5kHz.

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 illustrates one embodiment of web cleaning apparatus according to the present invention; and

Figure 2 shows graphically the relationship between an alternating voltage waveform, electrode current, and force on the surface of a web.

The present invention aims to deposit a significant charge of one sign on the web and then subject it to an electric field of the opposite sign to produce a force to dislodge particles from the surface of the web. Particles so dislodged can then be removed by an air stream passing over the surface of the web, or by suction applied to the web surface.

The apparatus shown in Figure 1 comprises a cylinder 12 over which a web 10 to be cleaned is passed. The surface of the cylinder 12 has a layer 14 of insulating material placed on it. The rest of the apparatus is positioned above the cylinder 12, and is mounted in a housing 16. An electrode 18 is positioned above the cylinder 12 so that the web 10 passes through a gap 20 formed between the cylinder 12 and the electrode 18. The electrode 18 has an insulating surface 19, and is connected to a high voltage alternating supply (not shown) which causes a corona discharge to occur in the gap 20.

In other applications, the insulating surface 19 and the layer 14 may not be required, the insulating surface being provided by the web itself.

An air supply arrangement 22 for supplying air to and removing air from the gap 20 is attached to an upper wall 24 of the housing 16 as shown. The arrangement 22 comprises a blower section 26 and a suction section 28 positioned adjacent one another with a dividing wall 30 therebetween. Each section 26, 28 has a respective opening 32, 34 which allows the passage of air into and out of that section.

The arrangement 22 also provides a method of positioning the electrode 18 above the surface of the cylinder 12. An insulating support member 36 is attached at one end to the arrangement 22 and at the

other to the electrode 18. The support member 36 is positioned between the openings 32, 34 thereby forming two ducts 38, 40, with further walls 42, 44. The walls 42, 44 are also made of insulating material so that the ducts 38, 40 so formed are non-conducting.

A member 46 is attached to the lower end 48 of wall 42 and extends perpendicularly to it. The member 46, in conjunction with the electrode 18, forms an air jet 50 through which air is directed towards the gap 20.

The apparatus operates as follows:

An alternating high voltage is applied to the electrode 18. Charging of the web and the production of forces into and away from the surface of the web occurs each half cycle of the alternating applied voltage.

As the voltage approaches its maximum absolute value, the strength of the electric field exceeds the breakdown strength for the air in the air gap 20, and a charge of the same sign as the applied electrode voltage is deposited on the surface of the web 10.

While the applied electrode voltage decreases from its maximum absolute value, a force is produced into the web.

When the applied voltage starts to increase (having changed sign), a force away from the surface of the web is produced. This force continues until enough charge has been deposited on the surface of the web to neutralise the previously deposited charge. Charging continues until the next maximum absolute value of applied voltage is reached. This charging provides the charge necessary to produce the forces into and away from the surface of the web during the next half cycle.

The electrostatic forces produced by the alternating voltage cause at least some of the

particles attached thereto to lift off the surface f the web 10, so that they can then be removed by air supplied to the surface of the web through the air jet 50, and removed from that surface by the suction section 28 of the air supply arrangement 22. The relationship between the alternating voltage waveform and the removal of particles from the surface of the web 10 is shown in Figure 2.

In Figure 2, an alternating voltage waveform 100 is shown. In this case, a regular sinusoidal waveform is shown but any other suitable alternating waveform can be used. A current waveform 102 and a force 'waveform' 104 are also shown. The waveforms 102 and 104 are depicted on the same time scale as the voltage waveform 100.

There are periods, indicated as 106, which due to the electrostatic forces acting away from the surface of the web, cause the particles to lift off the surface of the web 10.

The alternating voltage supply (not shown) is chosen to have a voltage which produces an electric field to loosen the particles from the surface of the web, the voltage having a maximum value to produce an electric field exceeding the breakdown strength of the air in the air gap 20. The electrode 18 is shaped so that breakdown occurs along the entire width of the web 10, and the corona discharge produced in the gap 20 is not concentrated at one point only.

The gap 20 is small, preferably less than 4mm, but any suitable value can be chosen according to the particular arrangement of the apparatus. The size of the air gap is determined by known parameters which affect the production of a corona discharge.

The alternating high voltage supply is chosen to have a frequency which is of several kHz, preferably in the range of 1 to 5kHz, although other frequencies may b workable according to the

particular embodiment of the apparatus. The frequency of the alternating voltage is related to the speed of the web. For the apparatus to work, the web must be under the electrode for at least half a cycle of the alternating voltage. However, it is preferred that the web is under the electrode for more than 2 cycles. With this in mind, lower frequencies can be used if the web is moving at a compatible speed.

The alternating voltage may have a regular sinusoidal waveform or it may have one of many other waveforms. In order for the apparatus to work effectively, the voltage supplied to the electrode should have:

a) a period of time when the voltage is suitable to allow the electrostatic forces (which cause the loosening of the particles) to take effect, and

b) a period of time when the voltage is suitable to produce a corona discharge thereby charging the surface of the web.

Because of these two requirements, an alternating square waveform cannot be used.

Although web cleaning apparatus according to the present invention is described with reference to a web which passes over a cylinder, the apparatus can be used equally well in an arrangement in which the web passes over a flat surface.

CLAIMS:

1. A method of cleaning web material comprising passing the web through an air gap, and removing particles from the web, characterized in that a corona discharge is produced across the air gap thereby generating electrostatic forces on the web and on the particles which cause at least some of the particles to lift off the surface of the web.

2. A method according to claim 1, wherein the corona discharge is produced by an alternating voltage supply.

3. A method according to claim 1 or 2, wherein particles are removed from the web by an air stream.

4. A method according to claim 3, wherein the air stream is generated by suction.

5. Web cleaning apparatus for use in a method according to any one of the preceding claims, the apparatus comprising:

a first surface,

a second surface spaced from the first surface and defining an air gap therebetween,

generator means for producing a corona discharge in the air gap, and

means for removing particles loosened by the corona discharge.

6. Apparatus according to claim 5, wherein at least one of the first and second surfaces is an insulating surface.

7. Apparatus according to claim 6, wherein the web itself constitutes an insulating surface.

8. Apparatus according to any one of claims 5 to 7, wherein the generator means is a high voltage alternating supply.

9. Apparatus according to any one of claims 5 to 8, wherein the means for removing loosened particles is a high velocity air stream.

10. Apparatus according to any one of claims 5 to 9, wherein the means for removing loosened particles includes suction means.

11. Apparatus according to any one of claims 5 to 10, wherein the generator means operates at a frequency between 1 to 5kHz.

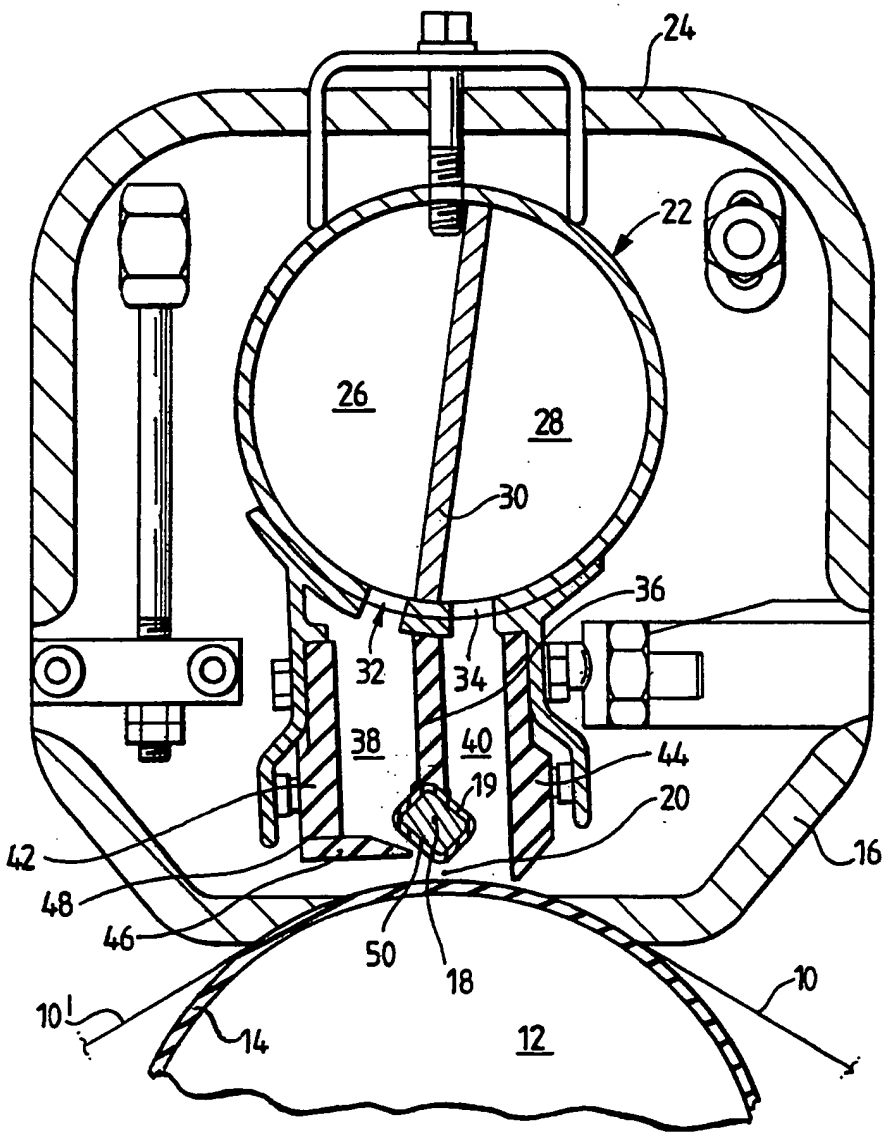

FIG. 1.

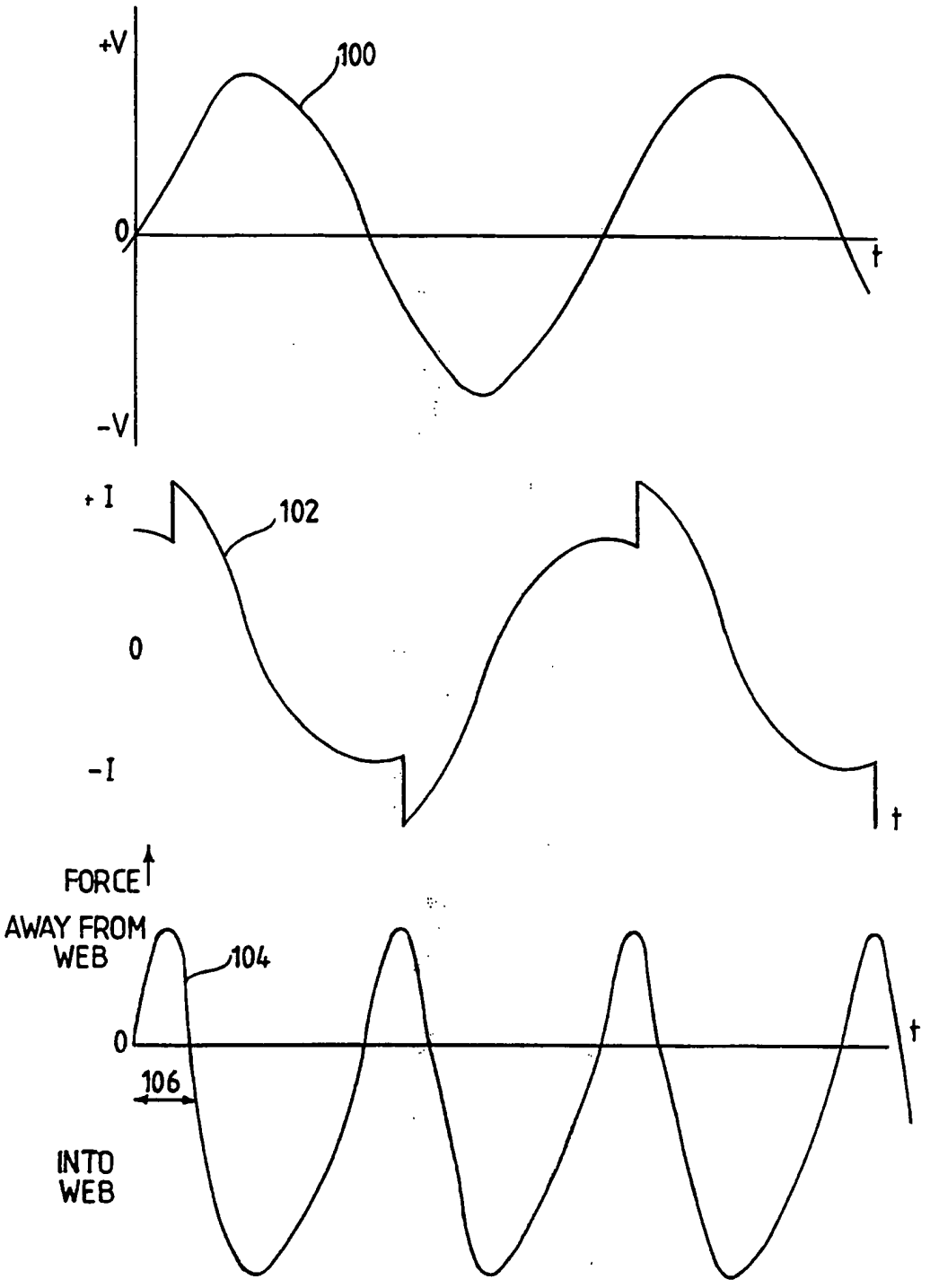

FIG.2.

INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 91/00283

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B08B6/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B08B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	FR,A,2179707 (CENTRAL GLASS CO. LTD.) 23 November 1973 see the whole document	1-11
Y	US,A,4727614 (G.K. SWISTUN) 01 March 1988 see abstract; figures	1-11
Y	EP,A,245526 (E.A. HAHNE) 19 November 1987 see abstract; figure 1	1-11

° Special categories of cited documents : [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29 APRIL 1991	27. 05. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	FRANKS N.M.

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

PCT/EP91/00283
SA 44223

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A-2179707	23-11-73	JP-A- 48103615	26-12-73
		JP-B- 52016354	09-05-77
		BE-A- 787650	18-12-72
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		US-A- 4835808	06-06-89